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SYNTHESIS AND ELECTROPHYSICAL PROPERTIES OF CERAMICS BASED ON $LaYO_3 \cdot YScO_3$ AT HIGH TEMPERATURES

V. A. Dubok[1] and V. V. Lashneva[1]

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High-density ceramics of the composition $LaYO_3 \cdot YScO_3$ with a total porosity around 0.5% was produced by chemical coprecipitation, molding, and sintering. The electric conductivity of this ceramics is measured and its conductance activation energy is determined. The results obtained can be used for making new types of thermosensitive resistors, as well as for synthesis of insulating materials.

The electrophysical properties of high-temperature oxides attract great attention in the search for new oxygen-ion-conducting materials operating steadily at high temperatures in oxidizing and reducing media. Complex oxides ABO_3 with the perovskite crystall structure are the objects of intense research, as they have long been used in engineering due to their unique electrical, magnetic, optical, and other properties [1 – 3]. Promising materials also include high-temperature perovskite compounds of rare-earth oxides (REO), in particular those formed by oxides of the beginning and end of the lanthanide series, whose electrophysical properties are sufficiently well studied [4, 5].

It is established that the electric conductivity of these compounds depends on nonstoichiometric disordering; in a wide range of partial oxygen pressures P_{O_2} it is mainly ionic and in air it is hole conductivity. With increasing temperature it changes in accordance with the exponential law and to a great extent depends on the content of impurities, which may either increase or decrease the conductivity and the conductance activation energy, as well as shift the range, in which conductivity does not depend on partial pressure of oxygen, toward higher or lower P_{O_2}.

In this context, phases based on perovskite REO compounds, i.e., phases with three rare-earth cations, are interesting for the development of new ceramic materials with preset properties.

The purpose of our work is to develop a technology for the synthesis of ceramics based on $LaYO_3 \cdot YScO_3$ (1 : 1) and study the dependence of its electrical conductivity on temperature and partial oxygen pressure in the temperature interval from 700 to 1550°C in media with controlled P_{O_2} (from atmospheric pressure to 10^{-15} Pa) under conditions as close as possible to thermodynamic equilibrium with the ambient medium.

The initial materials included powders of yttrium oxide Y_2O_3 (ItO-1), scandium oxide Sc_2O_3 (S-99), and lanthanum oxide La_2O_3 (LaO-1), which contained the main oxide in an amount at least 99.95% and impurities, as a rule, other oxides of rare-earth metals; nitric acid HNO_3 of grade "chemically pure," and aqueous solution of ammonia NH_4OH ("chemically pure").

The technology of preparing samples included continuous chemical coprecipitation of La, Y, and Sc hydroxides from aqueous nitrate solutions using an aqueous ammonia solution, drying of the precipitate at 200°C, calcination at 1200°C for 2 – 3 h, milling of powder obtained, molding sample preforms by isostatic molding in elastic rubber shells under a pressure of 400 – 500 MPa without a binder with preliminary vacuum-treatment, firing the preforms in a silit furnace at a temperature of 1200 – 1300°C for 2 h, and sintering in a vacuum furnace for 1 h at 1750 – 1800°C with subsequent oxidizing annealing in an air medium at a temperature of 1300°C for 2 h.

The synthesized samples were shaped as tablets of diameter 18 – 20 mm and thickness 3 – 4 mm and had a homogeneous microstructure. The open porosity of the samples did not exceed 0.5% and the average grain size was 6 – 7 μm. According to the petrographic analysis data the samples are optically heterogeneous and constitute a mixture of the optically isotropic and anisotropic phases (1 : 1).

The conductivity of the samples was measured by the two-probe methods using an alternating current of frequency 1500 Hz. The measurement error did not exceed 10%. Gas-permeable measuring electrodes were applied to samples by burning in platinum paste at a temperature of 1200°C. Partial oxygen pressure in the set was controlled using a ceramic

[1] Institute of Problems of Science of Materials, National Academy of Sciences of Ukraine, Kiev, Ukraine.

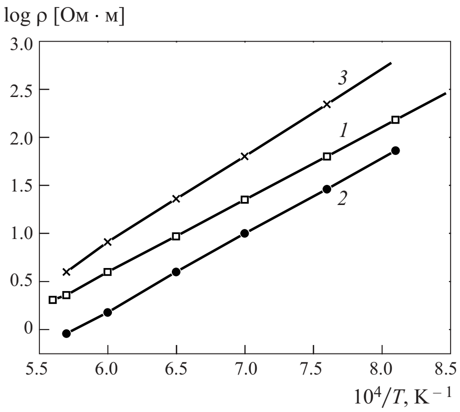

Fig. 1. Temperature dependences of electric resistivity ρ of $LaYO_3 \cdot YScO_3$ (*1*), $LaYO_3$ (*2*), and $YScO_3$ (*3*) in air.

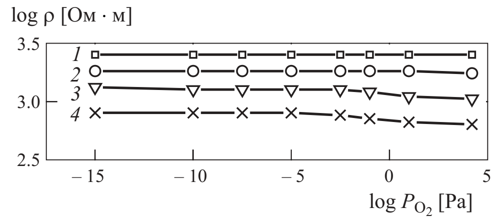

Fig. 2. Isotherms of resistivity ρ of $LaYO_3 \cdot YScO_3$ depending on partial oxygen pressure P_{O_2} in ambient medium at temperatures of 700 (*1*), 750 (*2*), 800 (*3*), and 850°C (*4*).

oxygen pump based on zirconium dioxide stabilized by yttrium oxide (with 8 mol.% Y_2O_3).

The results of measuring the dependence of the resistivity of $LaYO_3 \cdot YScO_3$ on temperature in air are shown in Fig. 1 (the temperature dependences of the resistivity of initial $LaYO_3$ and $YScO_3$ are indicated as well [5, 6]) and the dependence of the resistivity of $LaYO_3 \cdot YScO_3$ on partial oxygen pressure at a constant temperature is shown in Fig. 2.

It can be seen that the temperature dependence of the resistivity of $LaYO_3 \cdot YScO_3$ in air is described by the Arrhenius equation and within the temperature interval of 1000 – 1550°C it is represented by a straight line, whose inclination was used to calculate the conductance activation energy equal to 1.5 eV.

A correlation of the resistivity of samples of $LaYO_3 \cdot YScO_3$ with the resistivity of $LaYO_3$ and $YScO_3$ shows that the resistivity of $LaYO_3 \cdot YScO_3$ has an intermediate value: higher than that of $LaYO_3$ but lower than that of $YScO_3$.

Within the temperature interval of 700 – 850°C the electric resistivity $LaYO_3 \cdot YScO_3$ at a constant temperature virtually does not depend on partial oxygen pressure in the ambient medium, which is the evidence of the predominantly ionic conductance in this material.

The results obtained can be used to make new types of thermosensitive resistors, oxygen sensors, and other high-temperature electrochemical devices, as well as in the synthesis of insulating materials.

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